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Optimization of sugar level to develop healthy goat milk shrikhand

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Abstract
The present study was conducted to optimize the sugar level for preparation of goat milk shrikhand, which is the demand of present day health conscious consumer. Goat milk shrikhand was prepared with three different levels of sugar *i.e.* 20% (S1), 25% (S2) and 30% (S3) and evaluated for various physico-chemical properties and sensory attributes. pH values and moisture content decreased significantly ($P<0.05$) whereas titratable acidity, ash content and brix values increased significantly ($P<0.05$) with increased sugar content in goat milk shrikhand. Textural parameters *i.e.* consistency, cohesiveness and work of cohesiveness values were significantly ($P<0.05$) higher in S2 and S3 than S1. There was no significant difference in colour parameters among the treatments. The scores of all sensory attributes increased significantly ($P<0.05$) with increased sugar content and S3 had significantly ($P<0.05$) higher flavour, sweetness, mouth coating and overall acceptability scores than S1 and S2. Therefore, S3- goat milk shrikhand prepared with 30% sugar content was found as the best treatment.

Keywords: Goat milk shrikhand, sugar, optimization, textural and colour parameter, sensory evaluation

Introduction
India is leading milk producer in the world with 187.7 million tonnes of milk (NDDB, 2019) [1] due to advancement of technology, proper nutrition and appropriate manage mental practices. Livestock contributes about 9.2% in gross value added (GVA) and 26.2% in agriculture sector in India. The livestock population in India includes 302.3 million bovines, 74.3 million sheep, 148.9 million goats, about 9.1 million pigs and 851.8 million poultry. The rural and urban population of goat is 129.081 million and 6.092 million respectively in India. Total goat milk production in India is 6.09 million tones, out of which Rajasthan and Uttar Pradesh produce 2.31 million tonnes and 1.34 million tonnes respectively (DAHD, 2019) [2]. Goat milk production is a dynamic and growing industry that is fundamental to the wellbeing of millions people worldwide and is an important part of the economy in India. Goat milk is having better digestibility, alkalinity, buffering capacity and certain therapeautic values in medicine and human nutrition (Park and Chukwu, 1989; Park, 1994) [3, 4] in comparison to cow's or human milk. The goat milk microbiota is also considered a good source of novel bacteriogenic *Lactic acid* bacteria (LAB) strains that can be exploited as an alternative for use as bio preservative in food (Perin and Nero, 2014) [5]. It is also rich source of amino acid, being 20-40 folds higher than cow milk (Mehaia and Al-Kanhal, 1992) [6] which is involved in bile salt formation, osmoregulation, antioxidation, calcium transport and in the central nervous system (Redmond *et al.*, 1998) [7]. Minerals content such as calcium, potassium, magnesium and chloride as well as vitamin A, B, C, D, thiamin and niacin content of goat milk is higher than that of cow milk (Chandan *et al.*, 1992) [8]. Goat milk also contains higher content of three characteristics fatty acids *i.e.* caproic acid, caprylic and capric acid which are having medicinal values for patients suffering from malabsorption, childhood epilepsy, cystic fibrosis and gallstones (Haenlin, 1992) [9]; however these are responsible for intense "goaty flavour" which limits the acceptability of goat milk products among the consumers. Hence, flavour and aroma are main sensory attributes for acceptance of goat milk products, again addition of sugar may mask goaty flavor and help to improve overall acceptability of goat milk products. Therefore, present study was conducted to optimize the sugar level during preparation of goat milk shrikhand.

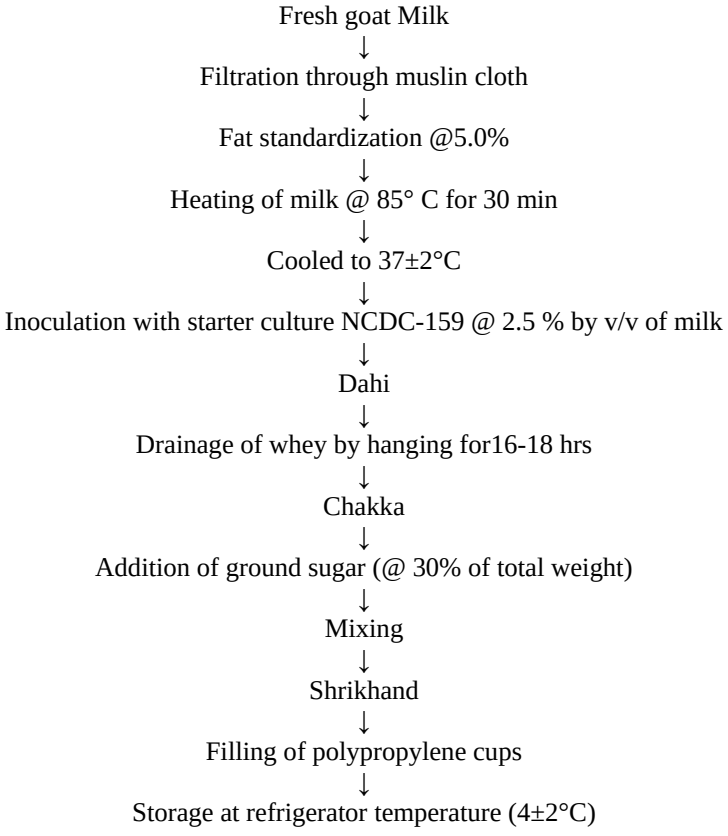
Materials and methods
The experiment was conducted in the Department of Livestock Products Technology, College of Veterinary Sciences and Animal Husbandry, U.P. Pt. Deen Dayal Upadhyaya Pashu

Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura, 281001 (UP), India. Fresh clean wholesome milk of goat was procured from Department of Veterinary Physiology, DUVASU, Mathura. Starter culture (NCDC-159) was procured from NDRI, Karnal which contained mixed culture of *Lactococcus lactis, Lactococccus diacetylactis* and *Lactococcus cremoris.* The culture was activated to as per the standard method and the activated parent culture was maintained by sub culturing and stored under refrigeration. Clean crystalline sugar was procured from local market of Mathura. All the chemicals used in the study were of analytical grade and procured from Hi Media laboratories (P) Ltd, Mumbai.

Preparation of Shrikhand

The shrikhand was prepared as per method described by Gupta *et al.* (2018) [10] with slight modifications.Preliminary trails were conducted to standardize the fat content and culture percentage in shrikhand. Fat content was standardized to 5% using Pearson square method whereas culture percentage was finalized at 2.5% v/v of milk on the basis of curd consistency.

Fresh goat milk was filtered through muslin cloth and then subjected to heat treatment at 85 °C for 30 minutes followed by cooling at 37±2°C. Milk was inoculated with NCDC-159 @ 2.5% by v/v of milk and incubated at 35-37 °C for 12-15 hours for proper curd setting. The curd thus obtained was transferred to clean muslin cloth and hanged for 16-18 hours in order to drain the whey to obtain chakka. The chakka was kneaded to have uniform consistency and then mixed with 30% ground sugar. Finally shrikhand was filled in pre sterilized thermorigid polypropylene cups and stored at under refrigeration at 4±2°C. In present study, following abbreviations were used for present experiment: S1- goat milk shrikhand prepared with 20% sugar, S2- goat milk shrikhand prepared with 25% sugar and S3- goat milk shrikhand prepared with 30% sugar.



Flow diagram 1: Preparation of shrikhand

Analytical methods

Physic-chemical properties

The pH of shrikhand was determined by using digital pH meter (WTW, Germany, model pH 330i) as per method given by Trout *et al.* (1992) [12]. Water activity of each sample was measured three times in duplicate using a water activity meter (Aqua Lab 3 TE, Inc. Pullman, WA) at Department of Goat Products Technology, CIRG, Makdhoom. Proximate parameters *viz*. moisture, protein, fat and ash content were estimated as per AOAC (1995) [11].

Textural and colour parameters

The texture profile analysis of shrikhand was done with the help of instrumental texture profile analyser (TA HD Plus Texture analyzer) for firmness, consistency, cohesiveness and work of cohesiveness (Bourne, 1978). Texture analyzer equipped with 5 kg load cell and back extrusion test using 35 mm cylinder probe was used for texture profile analysis of the samples. Other conditions (test descriptions) set for analyses were as follows:

Other conditions (test descriptions) set for analyses were as follows

Mode	:	Measure force in compression
option	:	Return to start
Pre-test speed	:	1 mm/sec
Test speed	:	1mm/sec
Post-test speed	:	10mm/sec
Distance	:	30mm
Trigger type	:	Auto (F) -10g
Trigger force	:	0.04903 N
Tare mode	:	Auto
Data acquisition rate	:	400pps
Probe	:	Back extrusion cell (A/BE)

The colour parameters *i.e.* lightness (*L**), redness (*a**) and yellowness (*b**) of the shrikhand were measured using Hunter colourimeter of Colour Tech PCM+ (Colour Tec Associates Inc. Clinton NJ, USA) at Department of Goat Products Technology, CIRG, Makdhoom.

Sensory evaluation

Sensory evaluation was conducted by experienced semi trained panellists using 8-point descriptive scale (where 1= extremely disliked and 8= extremely liked) (Keeton, 1983) for colour and appearance, flavour, texture, sweetness, mouth coating and overall acceptability.

Statistical analysis

The data obtained in the study on various parameters were statistically analyzed on 'SPSS-16.0' software package as per standard methods of Snedecor and Cochran (1995) [15]. Duplicate samples were drawn for each parameter and the experiment was replicated thrice (n=6). Sensory evaluation was performed by a panel of seven member judges three times, so total observations being 21 (n=21) Data were subjected to one way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between samples.

Result and discussion

Based on available literature, several preliminary trials were conducted to standardize the processing technology of goat milk shrikhand. The final formulation of goat milk shrikhand was optimized following the method prescribed by Gupta *et al.* (2018) [10] with slight modifications.

Physico-chemical properties

The physico-chemical properties of goat milk shrikhand prepared with different sugar levels are presented in table 1. The pH values and moisture content decreased while titratable acidity and ash content increased significantly ($P<0.05$) with increased sugar level in shrikhand. There was no significant difference in protein and fat content as well as water activity values. Brix values increased significantly ($P<0.05$) with increased sugar content in shrikhand. Higher brix values may be correlated to lower moisture content and higher sugar content in S2 and S3 as observed in present study resulting into more viscosity of final product. Torrico *et al.* (2019) [16] found positive correlation between sugar content and brix values in terms of thickness and viscosity of flavoured yogurt.

Table 1: Physico-chemical properties (Mean±SE) of goat milk shrikhand prepared with different sugar levels

Parameters	S1	S2	S3	Treatment Mean
pH	4.79^{a}±0.07	4.71^{b}±0.26	4.46^{c}±0.13	4.65±0.10
Titratable acidity	0.52^{c}±0.02	0.53^{b}±0.02	0.55^{a}±0.01	0.53±0.01
Moisture (%)	47.13^{a}±0.39	46.05^{b}±0.24	45.76^{c}±0.66	46.31±0.29
Protein (%)	5.84±0.24	6.16±0.09	6.29±0.04	6.09±0.11
Fat (%)	10.06±0.20	10.09±0.21	10.12±0.16	10.09±0.11
Ash (%)	0.70^{c}±0.02	0.72^{b}±0.02	0.76^{a}±0.04	0.73±0.02
Water activity	0.952±0.01	0.944±0.02	0.943±0.03	0.947±0.01
Brix value	29.28^{b}±0.12	31.51^{b}±0.16	32.57^{a}±0.14	31.12±0.16

- Overall means bearing different superscripts in a row (a, b, c, d.....) differ significantly ($P<0.05$)
- n=6
- S1- goat milk shrikhand prepared with 20% sugar
- S2- goat milk shrikhand prepared with 25% sugar
- S3- goat milk shrikhand prepared with 30% sugar

Textural and colour parameters

The texture profile analysis and colour values of goat milk shrikhand prepared with different sugar levels are presented in table 2.Textural parameters *i.e.* consistency, cohesiveness and work of cohesiveness values were significantly ($P<0.05$) higher in S2 and S3 than S1; however there was significant difference between S2 and S3. The possible reason for higher textural parameters values with increased sugar level might be the more viscous and firm product. These finding are also supported by Swain *et al.* (2014) [17] who stated that sugar played an important role for growth of *Lactobacillus* in fermented milk products due to plasmolysis and exoosmosis which in turn resulted into firm and compact texture of product. There was no significant difference in firmness values among the treatments. There was no significant difference in lightness, redness and yellowness values among the treatments, which might be due to no interference of white crystallized sugar in colour of shrikhand. Sofyan *et al.* (2013) [18] also observed no significant change in brightness, redness and yellowness values of less sugar containing cookies incorporated with different level of inulin.

Table 2: Texture profile analysis (Mean±SE) of goat milk shrikhand prepared with different sugar levels

Parameters	S1	S2	S3	Treatment Mean
Firmness	69.39±0.42	70.68±0.52	71.18±0.63	70.42±0.34
Consistency	44.64^{b}±0.23	47.47^{a}±0.34	48.26^{a}±0.23	46.79±0.40
Cohesiveness	34.35^{b}±0.17	35.88^{a}±0.31	36.23^{a}±0.08	35.48±0.21
Work of cohesiveness	25.32^{b}±0.18	27.08^{a}±0.23	30.81^{a}±0.27	27.73±0.27

- Overall means bearing different superscripts in a row (a, b, c, d.....) differ significantly (P<0.05)
- n=6
- S1- goat milk shrikhand prepared with 20% sugar
- S2- goat milk shrikhand prepared with 25% sugar
- S3- goat milk shrikhand prepared with 30% sugar

Sensory evaluation

The sensory scores of goat milk shrikhand prepared with different sugar levels are presented in table 3. Colour and appearance and texture scores of S2 and S3 were significantly (P<0.05) higher than S1; however there was no significant difference between S2 and S3. Higher colour and appearance scores with higher sugar content might be due to increased reducing sugar/amino acid interaction for the Maillard-type reaction forming brown polymers or melanoidins (Chevallier *et al.*, 2000) [19]. Flavour, sweetness, mouth coating and overall acceptability scores increased significantly (P<0.05) with increased sugar level in shrikhand. Aryana *et al.* (2017) [20] reported that the function of sugar in dairy products is to improve the flavour, addition of richness, improve keeping quality and texture of dairy products. S3 had significantly (P<0.05) higher sensory scores than S1 and S2 due to appropriate flavour, more sweetness and desirable firmness of the product. Therefore, S3- goat milk shrikhand prepared with 5.0% fat, 2.5% NCDC-159 starter culture and 30.0% sugar was found optimum.

Table 3: Colour estimation (Mean±SE) of goat milk shrikhand prepared with different sugar levels

Parameters	S1	S2	S3	Treatment Mean
Lightness (L*)	78.57±0.48	78.65±0.30	78.85±0.37	78.69±0.29
Redness (a*)	4.94±0.13	4.91±0.13	4.98±0.11	4.94±0.10
Yellowness (b*)	7.65±0.10	7.60±0.09	7.71±0.11	7.65±0.05

- n=6
- S1- goat milk shrikhand prepared with 20% sugar
- S2- goat milk shrikhand prepared with 25% sugar
- S3- goat milk shrikhand prepared with 30% sugar

Table 4: Sensory evaluation (Mean±SE) of goat milk shrikhand prepared with different sugar levels

Attributes	S1	S2	S3	Treatment Mean
Colour and appearance	6.51^{b}±0.05	7.06^{a}±0.08	7.12^{a}±0.04	6.73±0.04
Flavour	6.43^{c}±0.06	6.85^{b}±0.09	7.14^{a}±0.09	6.80±0.05
Texture	6.75^{b}±0.08	6.82^{a}±0.09	7.04^{a}±0.04	6.87±0.06
Sweetness	6.37^{c}±0.06	6.92^{b}±0.06	7.12^{a}±0.08	6.80±0.04
Mouth coating	6.45^{c}±0.08	6.78^{b}±0.05	7.18^{a}±0.04	6.80±0.04
Overall acceptability	6.69^{c}±0.07	6.98^{b}±0.10	7.21^{a}±0.06	6.96±0.05

- Overall means bearing different superscripts in a row (a, b, c, d.....) differ significantly (P<0.05)
- n=21
- S1- goat milk shrikhand prepared with 20% sugar
- S2- goat milk shrikhand prepared with 25% sugar
- S3- goat milk shrikhand prepared with 30% sugar

Conclusion

Sugar affects flavor, dimensions, color, texture and surface finish of dairy products, which becomes essential for goat milk products to mask their goaty flavour and to improve sensory scores. Addition of sugar improved texture of goat milk shrikhand in terms of consistency, cohesiveness and work of cohesiveness. There was no adverse effect on colour parameters, however sensory scores were significantly higher with higher level of sugar and product was very well acceptable with 30% sugar with pleasant flavour, sweetish aroma and soft mouth feel. Therefore it was concluded that nutritious goat milk shrikhand might be prepared with 5.0% fat, 2.5% NCDC-159 starter culture and 30.0% sugar with well acceptability.

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